A DYNAMIC SIMULATION MODEL OF THE ARTICULATION BETWEEN A REGIONAL OCCUPATIONAL TRAINING SYSTEM AND AN OCCUPATIONAL WORK FORCE

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Post-high school vocational training systems have functioned with a goal of satisfying employment demand through provision of trained workers and satisfying the needs of students through relevant training. Evaluation of goal attainment has included use of (1) follow-up strategies to assess the relatedness of employment to training and the length of tenure in training-related employment, and (2) longitudinal studies to explore the relationship between socio-economic variables and occupational choice and employment tenure.

Unfortunately, these strategies do not appropriately capture dynamic features of the labor market such as the changing level over time of employment demand or skill levels. Secondly, the information generated by these strategies does not aggregate into multiple year assessments of the articulation between training system output and labor market need. Further, the information does not suggest alternatives based on the dynamic relationship between training system administrator decision-making and labor market need, or between exogenous training system influences and labor market need.

Objectives of the Study

The study was conducted to (1) identify major variables and specify the boundary by which a vocational training system is constrained, (2) develop a simulation model capable of assessing the relationship of training system administrative decision-making with labor market need, and (3) explore via the model implications of selected training system policy on labor market need.

Description of the Model

A dynamic descriptive simulation model of a regional auto mechanics vocational training system was developed. The model was built using an industrial dynamics view of the phenomena[1] which directs attention to (1) the systematic relationship between variables comprising a human system,

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[1]The notation adopted in this paper is consistent with the syntax of the DYNAMO II-F language. Further information on the techniques and conventions of system simulation with DYNAMO are contained in Forrester (1968) and Pugh (1973). The full equation set is available from the senior author.

(2) the linkage between those variables and the set of hypotheses about that relationship, and (3) situations where changes through time are of interest. The nature of the linkage between variables was chosen on the basis of selected organizational principles concerning vocational training system behavior and its relationship with a labor market.

The model was limited to (1) simulating formal system behavior within a single economic development region of a north central state, (2) modeling selected demographic features of the development region, and (3) use and coordination of existent data files and training system organization and behavior information. The model was built using five subsystems: (1) WOKR, e.g., auto mechanics in the occupational work force, (2) WFND, e.g., the derived occupational need for auto mechanics, (3) OUTL, e.g., industry based auto mechanics vocational training, (4) P2OUT, e.g., public based auto mechanics vocational training, and (5) SKILL, e.g., the occupational skill level of auto mechanics. Policy relationships are linked to the system via information chains which contain delay functions. The system is multi-loop and nonlinear--to which the social processes probably belong--as such it is a system to be explored via dynamic simulations.

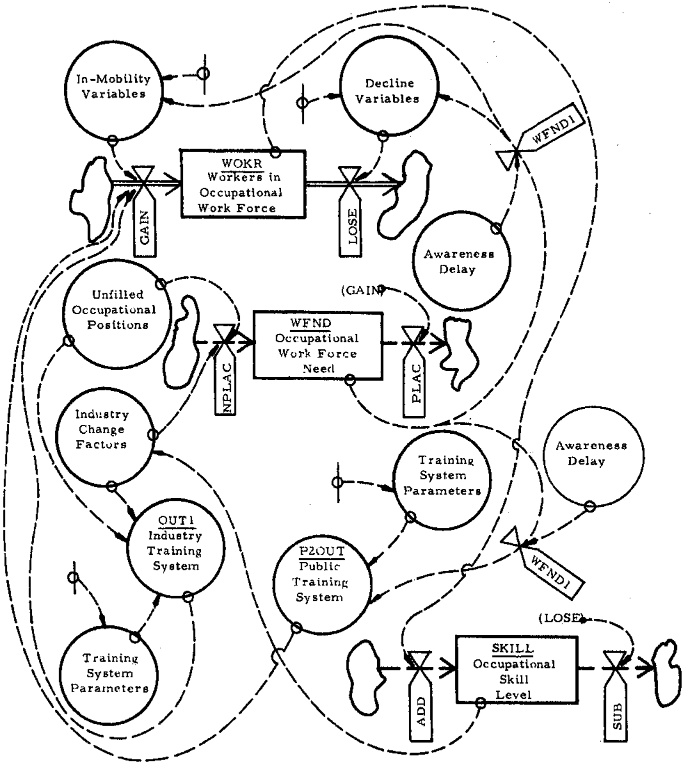
The management of an educational system implies future decision points. The feedback loop is the structure surrounding these points and the vehicle by which changes over time are communicated to all components of the system. The system depicted in Figure 1 is dynamically interactive since information flows between the several subsystems are present. For example, the growth of workers in a regional occupational work force (WOKR) is affected by the type of information program administrators in both private and public systems (OUTL and P2OUT) receive concerning industry change factors (technological change, shifts in industrial or agricultural base, etc.) or the perceived work force need. The degree of administrative action they deploy concerning resource commitment will depend upon the scale and type of information received, and the manner in which the information is processed. Their response will, in time, ultimately affect the number of auto mechanics occupying worker ranks since the outputs from the training system they manage are inputs into the auto mechanics work force.

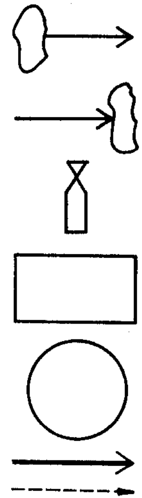
Description of the Subsystems

The regional labor market environment was modeled using three interconnected levels or subsystems. . . a "workers in occupation" system, an "occupational manpower demand" system, and an "occupational skill level" system. The training environment was modeled via a "public training" system and an "industry based" system. In the equations that follow .K refers to the present state of a variable, .J indicates the condition of a variable at a previous point in time, and .L indexes the next observation beyond the present. KL subscripts a rate variable and DT is the conventional delta time.

Development of the complete equation set for the five subsystems including information on program start-up, operation, close-down, other initialization data, and program decision rules are contained in Gunderson (1974).

FIGURE 1: Flow Chart of the Five Subsystems Comprising the Simulation Model





GAIN = increase in auto mechanics workers in Region A
LOSE = decrease in auto mechanics workers in Region A
WFND1 = smoothed information delay (substitutes for perceived work force need)
NPLAC = non placement of auto mechanics in work force in Region A
PLAC = placement of auto mechanics in work force in Region A
ADD = occupational skills added across Region A
SUB = occupational skills subtracted across Region A

*An underscored variable name indicates an individual subsystem.

Workers in Occupational Subsystem. This subsystem was built using regional phenomena surrounding auto mechanics employment levels. The number of auto mechanics comprising the regional work force (hereafter referred to as Region A) at time intervals simulated by the model was determined by the following equation:

(1) WOKR.K = WOKR.J + DT* (GAIN.JK-LOSE.JK)

where the number of auto mechanics (WOKR) in Region A at the present time is equal to the number of auto mechanics (WOKR) present at the previous point in time plus an elapsed time DT multiplied by the (quantity formed by the) number of new workers (GAIN) entering the work force minus the number of workers leaving the work force (LOSE).

The number of new auto mechanics entering the work force of Region A (GAIN.KL) is determined by the equation:

(2) GAIN.KL = OUT1.K + P2OUT.K + WALKIN.K + RLOFF.K

where OUT1.K equal program output from any (or all) types of private industry sponsored vocational auto mechanics training programs in Region A, P2OUT.K equals program output from public vocational-technical institute auto mechanics training programs in Region A, WALKIN.K equals the input of fully trained auto mechanics into Region A from other locations outside the region (also included is upward occupational mobility), and RLOFF.K equals the rehiring of auto mechanics previously laid off.

The number of auto mechanics leaving the work force in Region A (LOSE.K) is determined by the equation:

(3) LOSE.KL = MOBO.K + LOFF.K + DR.K

where MOBO.K is the fraction of the auto mechanics work force involved in occupational mobility, MOBG.K is the fraction involved in geographical mobility, LOFF.K is the fraction laid off due to seasonal employment cycles, and DR.K equals deaths and retirement within the work force.

Occupational Work Force Subsystem. Projecting work force need involves use of state employment demand data which represents the sum of individual employer perceptions of work force need. Recognizing that the reliability of such data can be low, this study also considered trend analysis of regional changes in technology which affects auto mechanics work force productivity and quality, and the productivity of the dominant industry. Work force need (WFND) was computed by equation (4):

(4) WFND.K = WFND.J + DT* (NPLAC.JK-PLAC.JK)

where work force need at the present time equals the work force need at the last time plus delta time multiplied by an increase in work force need minus a decrease in work force need.

An increase in work force need (NPLAC.KL) is determined by equation (5):

(5) NPLAC.KL = LOSE.K + AGVL.K + WFPR.K

where an increase depends upon the number of auto mechanics who have left the occupation or region (LOSE.K), plus the number of new auto mechanics work openings generated by a change in industrial employment and agricultural productivity (AGVL.K), plus the anticipated number of auto mechanic openings generated by a change in work force productivity (WFPR.K).

The number of auto mechanics reducing work force need (PLAC.KL) equals the number of workers (GAIN.K) entering the occupation (filling employment vacancies), equation (6):

(6) PLAC.KL = GAIN.K

Occupational Skill Level Subsystem. The equation set comprising this subsystem is linked to both the work force need and industry-based vocational training system. It is, however, the latter subsystem which provides the policy linkage necessary in order for the dynamics of the regional auto mechanics labor environment to be explored by modeling. The number of trainees in industry-based training programs is controlled by individual proprietor policy positions, positions which reflect a manager's view of his resources and the demand for services provided by his enterprise. One component in this policy mosaic is current quality of the auto mechanics work force. . . typically expressed as "a gut feeling that the quality of work in the shop is not up to snuff."

The level of skill (as a proxy, man-mean years of schooling was used) was determined in equation (7) by the rate at which skills are added (ADD) and the rate at which skills are lost (SUB).

(7) SKILL.K = SKILL.J + DT* (ADD.JK-SUB.JK)

The rate at which total skills are added (equation 8) was computed by summing the rates of adding skills due to geographic in-mobility (GMOBL), industry-based vocational training (TIVIT), and public-based vocational training (TPROG).

(8) ADD.KL = GMOBL.K + TIVIT.K + TPROG.K

The rate at which total skills are lost was computed (equation 9) by summing the rates of skill loss due to geographical out-mobility (TMOBG.K), occupational out-mobility (TMOBO.K), deaths and retirements (TDTH.K), and layoffs (TLOFF.K).

(9) SUB.KL = TMOBG.K + TMOBO.K + TDTH.K + TLOFF.K

Public Vocational Training Subsystem. The interface between training program output and auto mechanics employment with a regional work force is established through equation (10):

(10) P2OUT.K = (OUTP.K-(UNEM.K + UNREL.K + UNAVAIL.K))

where the measurement of output (P2OUT.K) at the present time equals the product of training output taking employment in Region A (OUTP.K) from which is subtracted the sum of student output unemployed (UNEM.K), at the present time, student output employed in occupations unrelated to auto mechanics (UNREL.K) at the present time (UNAVAIL.K).

Industry-Based Vocational Training Subsystem. As noted earlier, this subsystem represents a group of diverse economic endeavors, all of which provide auto mechanic services, and many of which provide training services. The timing, size, and scope of this training is subject to a blend of managerial policy, viz., perception of (1) work force need, (2) current quality of the employed auto mechanics work force, and (3) levels of demand for new types of service foisted on local repair agencies due to technological change.

Accordingly, equation (11) is formatted. . .

(11) INPUT.K = (IN.K*(WFND2.K + QOWFI.K)) + WFPR.K

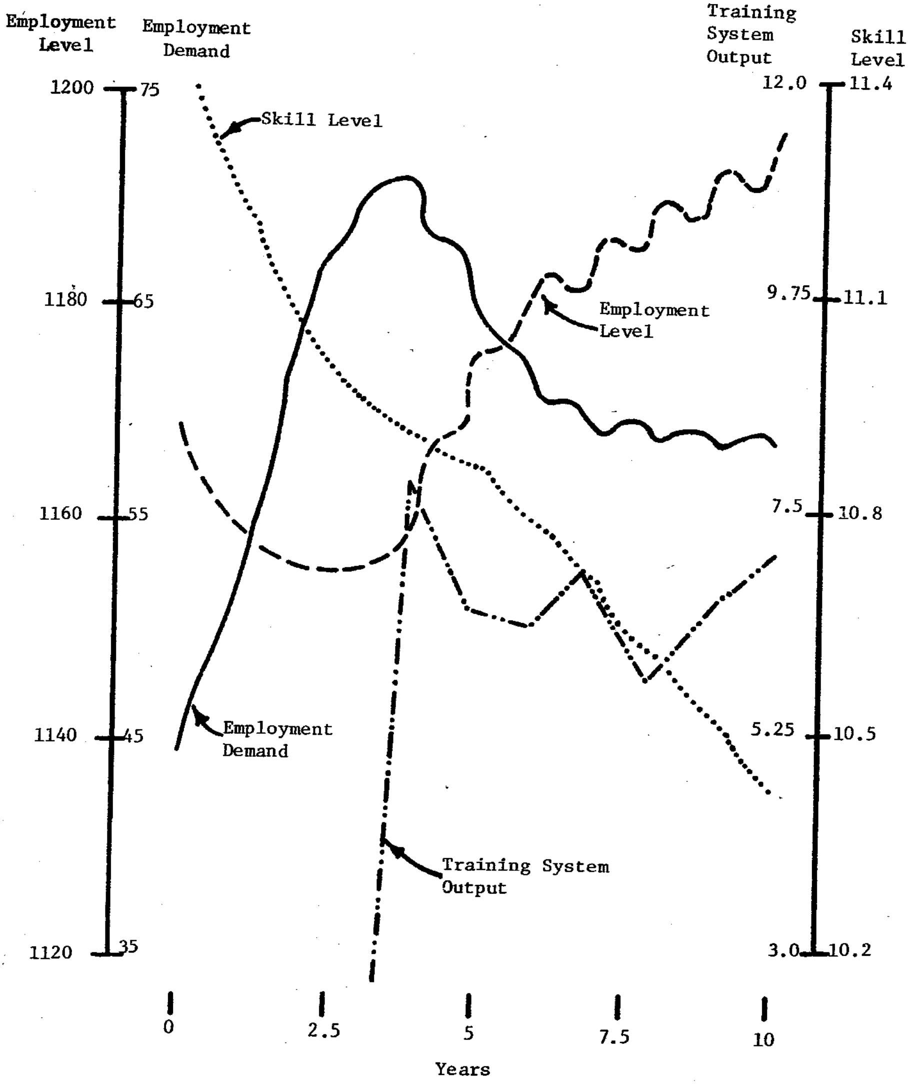
. . . where size of trainee input into local repair agency sponsored training programs at the present time (IN.K) is controlled by present managerial perception of the work force need (WFND2.K) and by assumptions concerning present quality of the work force (QOWFI.K). The presently perceived (by service agency managers) impact of a change in work force need due to technological change (WFPR.K) is added to student input. The linkage between variables of this subsystem and that of the other four is formalized in the equation sets used for modeling runs.

Model Generated Analysis of Current Training System Policies

Figure 2 presents plotted output of the computer simulation. It illustrates the dynamic behavior of regionally defined labor and training system variables for a period of 10 years, when allowed to function under existent exogenous variable and training system policy restraints. The regional variables plotted are the auto mechanics employment level (WOKR), the perceived employment demand for auto mechanics (WFNDI), public auto mechanics training system output (P2OUT), and auto mechanics skill levels (ASKILL). The scales for employment level and demand are shown on the left of the plot and the scales for training system output and skill level are shown on the right.

Three features of variable behavior are evident. First, once a public training system of the size currently operating in Region A generates student output (after year 3.5), the labor demand for auto mechanics drops by 10 percent and eventually oscillates around 59 workers a year. The simulation run possessed a built-in training system policy decision, viz., an employment demand of 44 auto mechanics was large enough to warrant starting at year .5 a single training program possessing characteristics (student intake, drops, graduates, and placements, etc.) similar to that of other like programs resident within Region A. It can be noted that the climb in demand for auto

FIGURE 2: Simulated Results of Basic vs. New Training System Policy



mechanics continues long after decisions to implement components of a training system have been made.

Secondly, the skill level (e.g., man-mean years of schooling) of auto mechanics in Region A falls throughout the duration of the simulation run. Due in large measure to the difference between adding and subtracting of skills due to dissimilar gain and loss rates within the occupational work force, regional skills drop with scarcely a pause. The combined "skill raising" effects of industry-based training, geographic in-mobility, deaths and retirements (e.g., the oldest workers possess less skill), and the public training systems are unable to intervene in a significant way. The research team's encounter with employer frustration over work force quality is therefore not surprising. The simulation run simply correlates with the observations of employers in Region A.

The third feature of interest is the fluctuating nature of training system output. The number of public training system generated auto mechanics students taking related employment in Region A is linked structurally, via a feedback loop which channels human perception, to the level of employment demand. The number of students taking related employment varies from a high of 7.8 per year to a low of 5.9 under system training conditions which reflect present managerial policy.

Full model operation demonstrates that in spite of substantial student intake (i.e., an average of 35.2 students per year) the training system attrition level was high (59 percent) and the percentage of trainees taking employment outside Region A (21 percent) could be greater than the regional training system advisory committee might desire. In addition, employment demand remained high throughout the model horizon.

An Analysis of a Change in Training System Managerial Policy

The basic model contained fixed drops/withdrawals and regional placement rates predicted upon analysis of data eminating from similar training systems. The rates had varied very little since 1947, however managerial action could be taken which might result in a favorable alteration. Two training system policy changes were made. . .one concerned instructional staffing, and the other involved vocational guidance: (1) a shift in policy was developed which required teacher training prior to employment rather than employ auto mechanics instructional staff directly from industry with little or no teacher training in advance of employment; (2) an increase in the system resource allocation devoted to vocational guidance activities was also developed.

The effect sought by the first policy change was to reduce student attrition within the training system through provision of a more nurturative training atmosphere. The effect sought by the second change was twofold: (1) in consort with the first policy change to reduce student attrition within the training system by making available more vocational guidance services; and (2) to reduce the number of system graduates who took employment unrelated to auto mechanics through provision of services (counseling, co-op work experiences, etc.) throughout the duration of each student's training experience.

The results generated by the policy set are indicated in Figure 3. A difference in system behavior is apparent. The number of workers in the occupation is larger, and manpower demand is diminished. The actual diminished need is equal to one year's training system output under the basic model equation set. Correspondingly, the number of workers in the occupation is greater by the same margin. One interesting feature of this simulation run was noted. . . unemployment among auto mechanic graduates doubled due to a declining work force need.

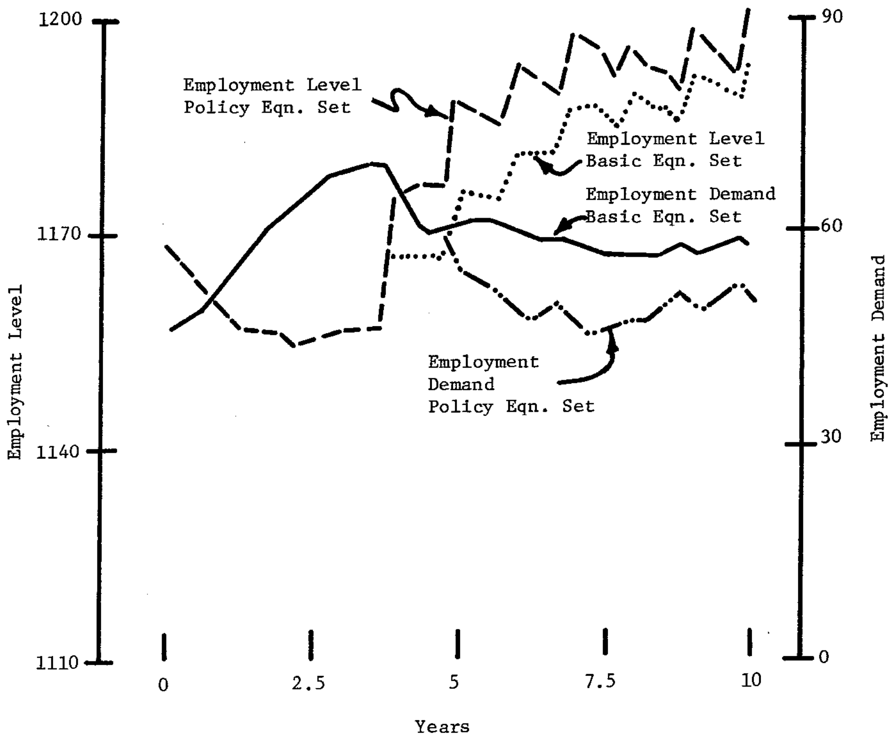
The impact upon the training system is more pronounced. Output is 53 percent greater under the policy equation set than with the basic model set. Administratively, the training system is now more easily justified. Its cost per student is considerably lower; hence it is more competitive when placed in the waiting queue for public funds. Secondly, its contribution to satisfy local manpower needs is more visible, both to the local employers of Region A, and to the advisory committee whose functions include, among other responsibilities, local legitimation of training system objectives and purposes. Thirdly, the human cost has been reduced--if one accepts the premise that drops and withdrawals represent costs whose recovery by society is impaired by lack of program completion.

Implications for Managerial Decision Making

Traditional vocational training system operation is composed of a series of discrete events, therefore care must be exercised when building a model which (1) relies on a continuous flow "view of the phenomena," and (2) articulates subsystem events essentially continuous in nature with those of discrete origin. The flow and ebb of workers residing in an occupational work force can be correctly simulated in difference equation format and translated by DYNAMO; however, an altered coding format must be employed to simulate discrete training events.

Finally, the strategy proposed by this study does not purport to replace other perfectly legitimate methods used by educational system administrators when making managerial decisions. The model does propose however, to replace the incomplete mental model used by far too many when making such decisions. Other types of studies and strategies have their place in the scheme of decision making; this strategy is suggested as another avenue which an administrator might use when generating useful information.

FIGURE 3: Analysis of Effects of Current Training System Policies



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